Remarks

Claims 1 – 35 previously presented have been cancelled without prejudice. Claims 36 – 66 are newly presented herein.

New Claims

This response adds new claims 36 – 66 to more clearly claim the subject invention. In particular, claims 36 – 51 define a method for catalytic combustion of a low concentration fuel, claims 52 – 65 define a catalytic combustion system, and claim 66 defines a catalytic combustion system for combustion of ventilation air and drainage gas derived from an underground coal mine.

Support for newly presented claim 36 is generally provided throughout the original disclosure which includes numerous references to a system for catalytic combustion of a low concentration fuel. Particular reference is made to page 2 lines 1 -5 which broadly refers to systems utilizing a gas with a substantially constant and low concentration of fuel. The features of compression ratio and combustion temperature may be found at page 14, line 34 – page 15 line 1 and page 16, lines 16 – 19 respectively. Preheating of the compressed fuel, expansion of the gas stream emitted from the combustor in a turbine and recirculation of at least part of the gas stream from the turbine after expansion can be found throughout the specification, for example at page 15, lines 5 – 16.

The features of the dependant claims 37 – 51 may be found in previously presented system and method claims. As noted, and as will be discussed in the following remarks, Applicants consider that the methods and systems for catalytic combustion of a low concentration fuel as now claimed more clearly define the subject invention.

The system of newly presented claim 52 includes a combination of originally presented claims 1, 4 and 10. Again, the dependant claims 53 – 65 find support in various claims that have been previously presented, and throughout the description of the invention as filed.

Claim 66 defines a specific application of the catalytic combustion system. That is, application to the combustion of ventilation air and drainage gas from an underground coal mine. Support for this claim and its various features may be found throughout the detailed description of the invention, with particular reference to the drawings.

The total number of pending claims in the present application is 31, three of which are independent. Given that claims fees for a total of 32 claims (three of which were independent) have already been paid by the Applicants, Applicants submit that no claim fees are due.

Drawing objections

The Examiner objects to Figure 1 of the drawings because Figure 1 is of poor line and print quality. Applicants provide herewith a replacement drawings page including an amended Figure 1.

The Examiner further objects to the drawings for not showing features recited in claim 26. Applicants submit that Figure 1 has been amended to include a reservoir 70 as was recited in originally filed claim 26 and disclosed on page 14, lines 25-31, of the specification.

As noted, amended Figure 1 includes a block identifying a reservoir 70. Consequential amendments are proposed to page 14, lines 25 – 31 as outlined above.

Specification amendments

This response amends the paragraph on page 14, lines 25-32, to identify a reservoir with reference number 70 and to correspond to the amended Figure 1.

The response amends the paragraph on page 17, lines 11-15, to recite a heat recovery boiler. Support for this amendment can be found in originally filed claim 14.

Amendment objections

The Examiner objects to amendments proposed on 20 August 2007. In particular, the Examiner has requested the reinstatement of the term "waste" before "heat boiler" on page 17, lines 11 – 15. This text is now proposed to be amended to describe a "heat recovery boiler 50". Support for this amendment may be found in claim 14 as originally presented. Applicants therefore submit that the proposed new wording finds support in the specification as filed.

Claim objections

The Examiner has objected to previously presented claim 17 noting that "a compressor" should read "the compressor" given reference to the compressor previously in claim 1. Applicants submit that this objection is moot in light of the newly presented claims set.

Claim rejections - 35 USC § 103

Newly presented claim 36 relates to a method for the catalytic combustion of a low concentration fuel. The method comprises the steps of compressing the low concentration fuel at a compression ratio of no greater than 3.5, preheating the compressed fuel, combusting the preheated compressed fuel at a temperature of no greater than 800°C and expanding the resultant gas stream in a turbine, wherein at least part of the gas stream is recirculated for preheating of the compressed fuel.

The closest counterpart to this claim is previously presented claim 31 directed to a method for producing electricity comprising the features of compressing the process gas stream to no more than 3.5 bar (absolute) and combusting a process gas stream in the presence of a catalyst to a temperature of less than 800°C.

Under the "claim rejection – 35 USC § 103" section of the Final Office Action the Examiner rejects previously presented claim 28 (on which previously presented claim 31 depends) and states (Final Office Action, page 8, paragraph 9):

"As for combusting the process gas in the presence of a catalyst to a temperature of less than 800°C, this is regarded as an obvious matter of using the workable ranges in the art for Prabhu. Note that the combustion temperature for methane and air can be calculated for a wide range of initial conditions which are covered by the Prabhu disclosure. The maximum initial temperature is 1000°F, and the initial temperatures should be kept significantly lower than this to avoid auto ignition."

The Examiner goes on to state:

"By varying the initial conditions, it is clear that temperatures of less than 800°C are well within the achievable range. It would have been obvious to one of ordinary skill in the art to vary the initial temperature of the process gas entering the combustor to achieve the claimed ranges, as an obvious matter of finding the workable ranges in the art."

Applicants agree that by varying the conditions of the system, including fuel concentration, pressure and initial temperature, one may achieve a combustion temperature of less than 800°C as presently claimed. However, Applicants respectfully submit that Prabhu teaches away from such a result, as outlined below.

Prabhu teaches the importance of selecting fuel concentration, pressure and initial temperature to avoid auto-ignition of the air/fuel mixture. In particular, Prabhu states that:

> "As an example, it has been determined through testing that a fuel concentration of 5% methane in air, at a pressure of 4 atmospheres will begin to ignite at 1000 degrees F., within 0.1 seconds. If the mixture is 2% of methane in air, then at the same pressure and temperature, it is known that ignition will not occur for 0.4 seconds. If for a particular configuration, it is determined that the actual time for gas to travel through the system is only 0.2 seconds, then a mixture of 2% methane in air or less for the same temperature-pressure situation will prevent auto-ignition and is inherently safe."

From this statement, Applicants respectfully submit that Prabhu aims to identify a threshold (i.e. at which auto-ignition occurs) that must not be exceeded. From this, one of skill in the art may arrive at various conditions that may be safely employed, thereby avoiding auto-ignition. However, whilst one would not want to venture too close to the identified conditions that would result in auto-ignition, one would want to maximize efficiency of the system. Therefore, Applicants submit that a person of skill in the art would, on reading Prabhu, identify the threshold for the conditions which avoid auto-ignition and select as high a fuel concentration as possible for a given compression ratio and initial temperature to provide for safe operation of the system whilst maximizing power output. Likewise, for a given fuel concentration as high a compression ratio and initial temperature as possible would be employed, within the threshold, to provide for maximum power output.

Taking the disclosure at column 8, lines 33-43, for example, Applicants note that a fuel mixture of 5% methane in air at a pressure of 4 atmospheres and an initial temperature of 1000°F will have a combustion temperature of about 1712°C. A fuel mixture of 2% methane in air at the same conditions will have a combustion temperature of about 1027°C. For lower concentration fuel mixtures, Applicants respectfully submit that higher pressures and initial temperatures would be selected to maximize power output from the systems of Prabhu.

Applicants desire a lean burn of a low concentration inlet fuel, for example to provide for the environmentally sensitive disposal of waste gases from underground coal mines. To that end, Applicants have found that such a burn may be achieved using a very low temperature of less that 800°C and a very low compression ratio of less than 3.5, and generally of approximately 2. The combination of low temperature and low compression ratio to achieve a lean burn is not appreciated, suggested or taught by Prabhu, the systems of which have a primary purpose of generating work, generally in the form of electricity.

The Examiner further rejects claim 31 on the basis that (Final Office Action, page 9, paragraph 11):

> "Lipinski et al teach a pressure out of 3.8 bar and teaches that using lower pressures would result in higher efficiencies (col.9, lines 55+). It would have been obvious to one of ordinary skill in the art to make the output pressure of the compressor less than 3.5 bar, in order to increase the thermodynamic efficiency."

Applicants respectfully submit that the low compression ratios suggested in Lipinski cannot be applied to the systems outlined in Prabhu as contended by the Examiner.

Furthermore, given the disclosure of Prabhu, Applicants respectfully submit that, contrary to the Examiners position, it would not have been obvious to a person of skill in the art to employ the relatively low compression ratios described in Lipinski in the systems of Prabhu as it would likely render the systems of Prabhu inoperable for the intended purpose and would change the principle operation of the systems of Prabhu.

Whilst Lipinski suggests that overall efficiency of the Brayton cycle may be maximized by lowering the pressure ratio, it is generally understood that when considering power generation high compression ratios and high temperatures are desirable. This is because high pressures and temperatures result in higher power output. To that end, it is generally understood in the art that a compression ratio of between 10 and 30 is required for

efficient operation of Brayton cycle systems. This may be appreciated from any number of technical publications in the field of Brayton cycle gas turbine engines. Similarly, it is generally appreciated that combustion temperatures well in excess of 800°C are desirable in such systems in order to maximize power generation. To that end, a person of skill in the art will readily appreciate that the temperatures used in such systems have steadily increased over the past decades, limited solely by the materials of construction of the turbine.

Applicants respectfully submit that the suggestion made in Lipinski must be taken in context. In particular, Applicants note that although Lipinski does suggest the use of relatively low pressure ratios, Lipinski also appreciates that when using such low pressure ratios it is necessary to add heat to the fuel during combustion to raise the temperature of the compressed air. Applicants refer the Examiner to Lipinski at column 10, lines 12 – 15 where additional heat is added to raise the temperature of compressed air to well over 800°C. Applicants respectfully submit that this is generally appreciated in the art. That is, the use of low compression ratios necessitates injection of heat during combustion to improve the overall efficiency and power generation of the system.

The Examiner contends that it would have been obvious to a person of skill in the art, on reading Lipinski, to employ a compression ratio of less than 3.5 bar in the system of Prabhu. In line with the comments above, Applicants respectfully disagree and submit that if this were the case, the person of skill in the art would also employ a relatively high initial temperature (and therefore combustion temperature) and/or a relatively high fuel concentration to maximize power output, whilst not exceeding the maximum threshold for auto-ignition of the fuel. The use of a low compression ratio and low combustion temperature for a given fuel concentration in the system of Prabhu, such that the conditions are well below the threshold for auto-ignition, would likely render the system of Prabhu inoperable for its intended purpose (i.e. generation of work, such as electricity).

Furthermore, the principle operation of the system of Prabhu is to generate work, generally in the form of electricity. Applicant respectfully submits that if the compression ratio disclosed in Lipinski (i.e. a compression ratio of 3.8) is employed in the system of Prabhu, in combination with a low combustion temperature (i.e. of less than 800°C), the principle operation of Prabhu would not be satisfied. That is, the work (electrical) output would not be satisfactory.

Newly presented claims 37 and 38 more specifically define the compression ratio employed in the method of the invention. Basis for these claims may be found at page 2, lines 32-35 of the description. Applicants respectfully submit that there is no teaching or suggestion in the references of record for such compression ratios. Particularly, if the Examiner forms the opinion that the above submissions are unpersuasive, Applicants respectfully submit that the disclosure of a compression ratio of 3.8 in Lipinski, which is admittedly described in that reference as "a relatively low pressure ratio", cannot be considered to render a compression ratio of approximately 2 (as defined in newly presented claim 38) obvious.

Newly presented claims 39-41 provide more detailed definitions for the process temperatures employed in the invention. Applicants submit that if the above arguments are considered unpersuasive by the Examiner, the additional features of these claims cannot be considered obvious in light of the art of record.

Newly presented claim 52 relates to a catalytic combustion system including a compressor, pre-heater, catalytic combustor and turbine, where at least a part of the gas stream passing from the compressor to the turbine is recirculated from the turbine to the pre-heater. The compressor operates at a compression ratio of no greater than 3.5, whilst the gas stream received by the turbine has a temperature of less than 800°C. This claim represents a combination of originally presented claims 1, 4 and 10. It also closely reflects a combination of previously presented claims 4 and 10.

With regard to the temperature of operation, in the Final Office Action the Examiner states, referring to Prabhu (Final Office Action, page 5, paragraph 7):

"wherein the inlet stream of the turbine has a temperature of less than 800°C (1000°F is much less than 800°C, see col. 8, lines 33+)"

This disclosure in Prabhu refers to the inlet temperature of the fuel mixture to the combustor. As noted above, under the conditions described, the temperature of combustion, and therefore the temperature of the gas stream entering the turbine, is much higher (i.e. 1712°C for a 5% fuel mixture and 1027°C for a 2% fuel mixture). Applicants respectfully submit that Prabhu therefore fails to teach or suggest operation of systems at combustion temperatures (i.e. turbine gas inlet temperatures) of less than 800°C. As outlined above, the purpose of the system of Prabhu is to generate work, generally in the form of electricity. Therefore, compression ratios, combustion temperatures and fuel concentrations would be selected by a person of skill in the art in order to maximize power output from the system. For relatively low concentration fuel mixtures, a person of skill in the art on reading Prabhu would be motivated to employ relatively high compression ratios and combustion temperatures to maximize power output from the system, whilst not exceeding auto-ignition conditions. The present invention, on the other hand, aims to provide a system for the lean burn of a low concentration inlet fuel, for example to provide for the environmentally sensitive disposal of waste gases from underground coal mines. To that end, Applicants have found that such a burn may be achieved using a very low temperature of less that 800°C and a very low compression ratio of less than 3.5, and generally of approximately 2.

In the Final Office Action the Examiner states (Final Office Action, page 7, paragraph 8):

"As for the pressure output from the compressor being less than 3.5 bar, Lipinski et al teach a pressure out of 3.8 bar and teaches that using lower pressures would result in higher efficiencies (col.9, lines 55+). It would have been obvious to one of ordinary skill

in the art to make the output pressure of the compressor less than 3.5 bar, in order to increase the thermodynamic efficiency."

As previously noted, Applicants respectfully submit that this statement must be taken in context. Whilst a relatively low compression ratio is referred to in Lipinski, in order to facilitate its use heat must be injected into the compressed air during combustion (col. 10, lines 12-15). Furthermore, contrary to the disclosure in Lipinski, it is generally accepted that for Brayton cycle systems efficiency of the system and power output increase with increasing compression ratio and combustion temperature.

Further to the above, presently availably turbines for use in gas turbine systems are generally designed to operate at relatively high (i.e. from 10-30) compression ratios and pressures. In order to improve the efficiency of the present invention, Applicants have arrived at a turbine design specifically devised for low pressure use. Although Prabhu refers to relatively low pressures, Applicants respectfully submit that application of the pressure described in Lipinski (i.e. 3.8 bar), would likely render the system of Prabhu inoperable for its intended purpose. Applicants submit that this is particularly the case if one takes the combination of relatively low combustion temperature and low compression ratio as defined in the newly presented claims.

Newly presented claim 66 relates to a catalytic combustion system specifically designed for the catalytic combustion of ventilation air and drainage gas from an underground coal mine. The system, as will be appreciated by one of skill in the art, is designed for the lean burn of a low concentration fuel derived from the ventilation air and the drainage gas and has a primary objective of providing for the environmentally sensitive disposal of waste gas, in the form of drainage gas and methane containing ventilation air, from underground coal mines.

Applicants respectfully refer to the above comments which may be equally applicable to newly presented claim 66.

Conclusion

In view of the above, reconsideration and allowance of all the claims are respectfully solicited.

The Commissioner is authorized to charge any additional fees which may be required or credit overpayment to deposit account no. 12-0415. In particular, if this response is not timely filed, then the Commissioner is authorized to treat this response as including a petition to extend the time period pursuant to 37 CFR 1.136 (a) requesting an extension of time of the number of months necessary to make this response timely filed and the petition fee due in connection therewith may be charged to deposit account no. 12-0415.

I hereby certify that this document is being transmitted to the Patent and Trademark Office via electronic filing.

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